**Spins - Inverse design software for nanophotonic structures**

**Summary of invention:**
This software suite called **Spins**, automates the design of arbitrary nanophotonic devices by leveraging gradient-based optimization techniques that can explore a large space of possible designs. The resulting devices have higher efficiencies, smaller footprints, and novel functionalities. **Spins** is now being licensed to any interested parties through Stanford's Office of Technology Licensing (OTL). **Spins-B** is an open source version available on Github (OTL).

**Problem:** Currently, the design of photonic devices and systems remains extremely labor-intensive and requires engineers with detailed knowledge and extensive experience.

**Solution:** To improve upon traditional photonics design methods, the Vuckovic group at Stanford University has developed **Spins**, an automated photonics design suite that can:

- Automatically design photonic devices with no human guidance?
- Design any passive, linear photonic element?
- Efficiently search the full space of fabricable devices using gradient-based optimization?
- Produce designs that are significantly more compact, have higher performance, and potentially realize novel functionalities?
- Incorporate fabrication constraints to ensure devices are readily fabricable?
- Streamline the design process for planar waveguide devices and grating couplers through the use of provided device design kits which only require the user to input high level parameters

**Stage of Development:**
Prototypes - The team designed and experimentally demonstrated a spatial-mode demultiplexer, wavelength demultiplexer, compact broadband power splitter and directional coupler.

A module of Spins for grating couplers is described in Stanford docket S18-019 Fully-automated design of grating couplers.

Licenses

- Commercial site and distribution licenses are available.
- Academic and US government lab licenses are available at a discounted price. Contact the Stanford Office of Technology Licensing Office for more details.

Applications

- Designing innovative structures for efficient optical devices
  - Examples include silicon photonics components, such as power splitters, wavelength demultiplexers, fiber-to-chip grating coupler design, mode converters, metasurface design, quantum circuits (photonic and microwave) LEDs, solar cells, lasers designs

Advantages

- Fully automated and efficient
  - Allows user to 'design by specification'
  - Uses gradient-based optimization methods not derivative-free optimization methods which are computationally inefficient and only work well for small numbers of degrees of freedom
- Devices can be easily fabricated by standard lithography techniques

Publications

• Inverse-designed non-reciprocal pulse router for chip-based LiDAR, Ki Youl Yang, Jinhie Skarda, Michele Cotrufo, Avik Dutt, Geun Ho Ahn, Mahmoud Sawaby, Dries Vercruysse, Amin Arbabian, Shanhui Fan, Andrea Alù, Jelena Vu?kovi? Nature Photonics (2020)


• Inverse design and demonstration of a compact on-chip narrowband three-channel wavelength demultiplexer, Logan Su, Alexander Y. Piggott, Neil V. Sapra, Jan Petykiewicz, Jelena Vu?kovi?. ACS Photonics (2018)


• Inverse design and implementation of a wavelength demultiplexing grating coupler, Alexander Y. Piggott, Jesse Lu, Thomas M. Babiniec, Konstantinos G. Lagoudakis, Jan Petykiewicz, Jelena Vuckovic, Scientific Reports 4, 7210, (2014) [Supplementary info]

• Nanophotonic computational design, Jesse Lu and Jelena Vuckovic, Optics Express Vol. 21, 11, pp. 13351-13367 (2013)

• Spins Overview
• Spins Tutorial
• Spins Usage Example
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